New Jersey Stormwater
Best Management Practice Manual

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CHAPTER 9.5

Standard for Infiltration Basins

Definition

An infiltration basin is a facility constructed within highly permeable soils that provides temporary storage of runoff during rain events. An infiltration basin does not normally have a structural outlet to discharge runoff from the Stormwater Quality Storm. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage for both stormwater quality and quantity management. The adopted TSS removal rate for infiltration basins is 80 percent.

It should be noted that a dry well is a specialized infiltration facility intended only for roof runoff. Dry wells are discussed in Section 9.3.

Purpose

Infiltration basins are used to remove pollutants and to infiltrate stormwater back into the ground. Such infiltration also helps to reduce increases in both the peak rate and total volume of runoff caused by land development. Pollutant removal is achieved through filtration of the runoff through the soil as well as biological and chemical activity within the soil.

Conditions Where Practice Applies

The use of infiltration basins for stormwater quality control is feasible only in small drainage areas where soil is sufficiently permeable to allow a reasonable rate of infiltration. Therefore, infiltration basins can be constructed only in areas with soils in Hydrologic Soil Groups A or B. Additional soil infiltration requirements are presented below.

Infiltration devices are not appropriate in areas producing high concentrations of suspended particles or other pollutants. In addition, infiltration facilities must not be used in the following locations:

1. Areas where petroleum products, herbicides, pesticides or solvents – particularly with soluble heavy metals or toxic organics – may be loaded or unloaded, stored or applied within an infiltration basin's drainage area.
2. Areas where hazardous materials are expected to be present in greater than 'reportable quantities' as defined by U.S. Environmental Protection Agency (USEPA) in the Code of Federal Regulations (40 CFR 302.4).
3. Areas such as gas stations and vehicle maintenance facilities where there is a high risk of spills of toxic materials.
4. Areas with industrial stormwater exposed to source material. Source material means any material(s) or machinery, located at an industrial facility that is directly or indirectly related to process, manufacturing or other industrial activities, which could be a source of pollutants in any industrial stormwater discharge to groundwater. Source materials include, but are not limited to: raw materials; intermediate products; final products; waste materials; by-products; industrial machinery and fuels; and lubricants, solvents and detergents that are related to process, manufacturing or other industrial activities that are exposed to stormwater.
5. Where the soil around and below the infiltration basin does not have the necessary permeability to infiltrate the entire Stormwater Quality Storm runoff volume.
6. Where infiltration basin installation would create a significant risk for groundwater mounding, which may cause basement seepage or adversely impact a septic system's disposal field.
7. Where infiltration basin installation would create a significant risk of groundwater pollution due to the basin's inability to effectively treat soluble pollutants.

An infiltration basin must not to be placed into operation until the contributing drainage area is completely stabilized. Basin construction must either be delayed until such stabilization is achieved, or upstream runoff must be diverted around those systems construction prior to stabilization. Such diversions must continue until stabilization is achieved.

Design Criteria

The components of a typical infiltration basin are shown in Figure 9.5-1. Additional details of each component are described below.

A. Storage Volume, Depth, and Duration

Infiltration basins should be designed to store and infiltrate the runoff volume generated by the 1.25-Inch/2-Hour Stormwater Quality Storm. Techniques to compute this volume are discussed in Chapter 5. The lowest elevation in an infiltration basin must be at least two feet above the seasonal high groundwater table. This distance must be measured from the bottom of the sand layer, as shown in Figure 9.5-1.

To enhance safety by minimizing standing water depths, the vertical distance between the basin bottom and the maximum Stormwater Quality Storm water surface in surface infiltration basins should be no greater than two feet wherever practical.

It is important to note that the use of infiltration basins is recommended only for the Stormwater Quality Storm and smaller storm events. As such, the infiltration basin standards in this manual cannot be extrapolated to larger storm events. Use of infiltration basins for larger storm events and the requirements by which such basins are to be designed, constructed, operated and maintained should be discussed with the applicable reviewing agency.

B. Infiltration Rates

The minimum design infiltration rate of the soil below an infiltration basin is 0.5 inches per hour. In addition, the design infiltration rate of the soil must be sufficient to fully drain the Stormwater Quality Storm runoff volume within 72 hours. This design infiltration rate must be determined by field or laboratory testing. Since the actual infiltration rate may vary from test results and may also decrease over time due to soil bed consolidation or the accumulation of sediments removed from the treated stormwater, a factor of safety of two must be applied to the tested infiltration rate to determine the design infiltration rate. Therefore, if the tested infiltration rate of the soil bed material is four inches/hour, the design rate would be two inches/hour = (4 inches per hour/2). This design rate would then be used to compute the system's Stormwater Quality Storm drain time.

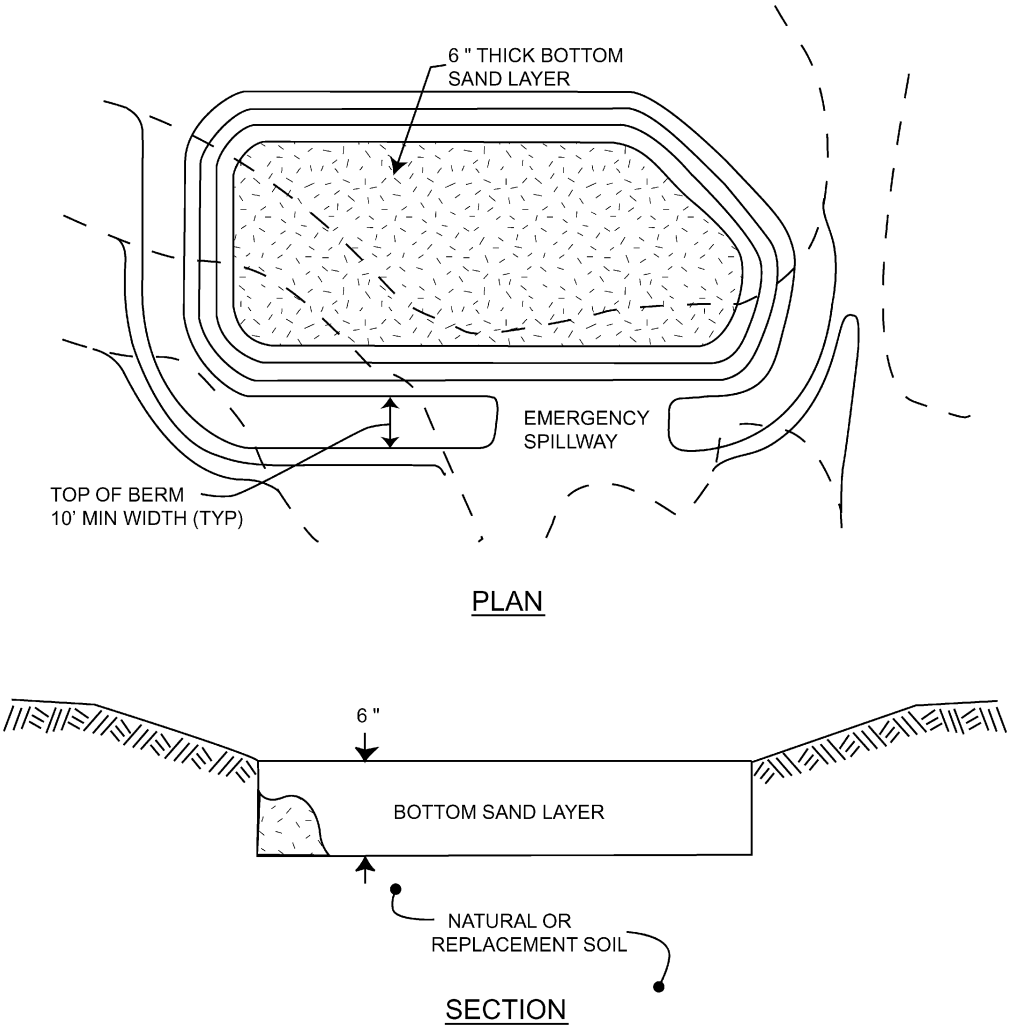
C. Bottom Sand Layer

To help ensure maintenance of the design infiltration rate over time, a six-inch layer of sand must be placed on the bottom of an infiltration basin (see Figure 9.5-1). This sand layer can intercept silt, sediment and debris that could otherwise clog the top layer of the soil below the basin. The sand layer will also facilitate silt, sediment and debris removal from the basin and can be readily restored following removal operations. The sand layer must meet the specifications of a K-5 soil. This must be certified by a Professional Engineer licensed in the State of New Jersey.

D. Overflows

All infiltration basins must be able to convey overflows to downstream drainage systems in a safe and stable manner. Infiltration basins that are classified as dams under the NJDEP Dam Safety Standards (NJAC 7:20) must also meet the overflow requirements of these Standards.

Figure 9.5-1: Infiltration Basin Components



NOTES

1. 6" THICK BOTTOM SAND LAYER SHALL CONSIST OF K5 SAND WITH NO MORE THAN 15% FINES AND SHALL HAVE A MINIMUM INFILTRATION RATE OF 20 INCHES PER HOUR.
2. NO CONSTRUCTION EQUIPMENT PERMITTED IN THE AREA OF THE BASIN BOTTOM.
3. SEE TEXT FOR ADDITOINAL REQUIREMENTS AND DESCRIPTIONS.

Courtesy of T&M Associates

E. On-Line and Off-Line Systems

Infiltration basins may be constructed either on-line or off-line. On-line systems receive upstream runoff from all storms, providing runoff treatment for the Stormwater Quality Storm and conveying the runoff from larger storms through an overflow. With the proper soil and drainage area conditions, an infiltration basin may also be combined with a detention basin to provide runoff quantity control as well in the detention portion of the basin. In such systems the invert of the lowest stormwater quantity control outlet is set at or above the maximum Stormwater Quality Storm water surface.

In off-line infiltration basins, most or all of the runoff from storms larger than the Stormwater Quality Storm are diverted past the system. This not only reduces the size of the required basin overflow, but also reduces the basin's long-term pollutant loading and associated maintenance.

F. Subsurface Infiltration Basins

A subsurface infiltration basin is located entirely below the ground surface. It may consist of a vault, perforated pipe, and/or stone bed. However, due to the greater difficulty in removing silt, sediment and debris, all runoff to a subsurface infiltration basin must be pretreated by an upstream BMP. This pretreatment must remove 80 percent of the TSS in the runoff. See Chapter 4 for a listing of TSS removal rates for various BMPs.

Following pretreatment, additional TSS removal will then be provided by the subsurface infiltration basin as the secondary BMP in a treatment train. Computation of the total TSS removal rate is described in Chapter 4.

G. Basis of Design

The design of an infiltration basin is based upon Darcy's Law:

$$Q = KIA$$

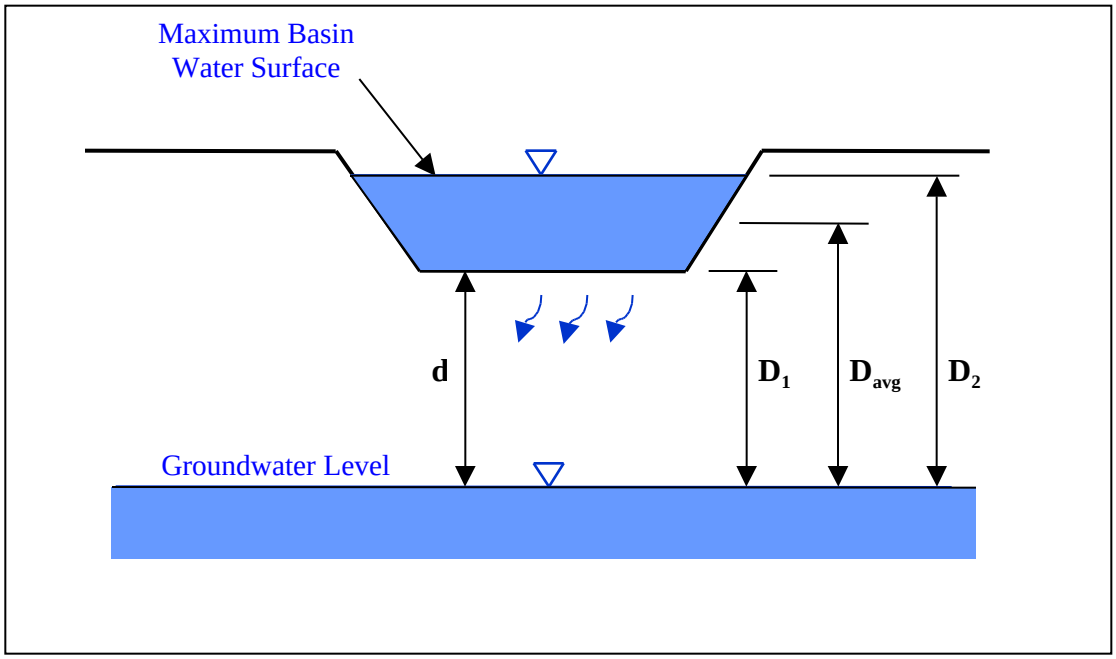
where:

Q = the rate of infiltration in cubic feet per second (cfs)
K = the hydraulic conductivity of the soil in feet per second (fps)
I = the hydraulic gradient
A = the area of infiltration in square feet (sf)

As shown in Figure 9.5-2 below:

Average Hydraulic Gradient = D_{avg}/d
Minimum Hydraulic Gradient = D_1/d
Maximum Hydraulic Gradient = D_2/d

Figure 9.5-2: Schematic of Darcy's Law



The hydraulic conductivity is either field measured or laboratory measured for the soil on site. A number of percolation tests should be done to obtain a reliable measurement of permeability of the underlying soil.

Operation and Maintenance

Effective infiltration basin performance requires proper operation and regular maintenance. Chapter 8 contains information and requirements for preparing an Operation and Maintenance Plan for stormwater management facilities, including infiltration basins. Specific operation and maintenance requirements for infiltration basins are presented below. These requirements must be included in the system's Operations and Maintenance Plan.

A. General Maintenance

All infiltration basin components expected to receive and/or trap debris and sediment must be inspected for clogging and excessive debris and sediment accumulation at least four times annually as well as after every storm exceeding one inch of rainfall. Such components may include bottoms, riprap or gabion aprons, and inflow points. This applies to both surface and subsurface infiltration basins.

Sediment removal should take place when the basin is thoroughly dry. Disposal of debris and trash should be done at suitable disposal/recycling sites and in compliance with all applicable local, state and federal waste regulations.

Studies have shown that readily visible stormwater management facilities like infiltration basins receive more frequent and thorough maintenance than those in less visible, more remote locations. Readily visible facilities can also be inspected faster and more easily by maintenance and mosquito control personnel.

B. Vegetated Areas

Mowing and/or trimming of vegetation must be performed on a regular schedule based on specific site conditions. Grass should be mowed at least once a month during the growing season. Vegetated areas must also be inspected at least annually for erosion and scour. The structure must be inspected for unwanted tree growth at least once a year.

When establishing or restoring vegetation, biweekly inspections of vegetation health should be performed during the first growing season or until the vegetation is established. Once established, inspections of vegetation health, density and diversity should be performed at least twice annually during both the growing and non-growing season. If vegetation has greater than 50 percent damage, the area should be reestablished in accordance with the original specifications and the inspection requirements presented above.

All use of fertilizers, mechanical treatments, pesticides and other means to assure optimum vegetation health must not compromise the intended purpose of the bioretention system. All vegetation deficiencies should be addressed without the use of fertilizers and pesticides whenever possible.

All vegetated areas should be inspected at least annually for unwanted growth, which should be removed with minimum disruption to the remaining vegetation and basin subsoil.

C. Structural Components

All structural components must be inspected for cracking, subsidence, spalling, erosion, and deterioration at least annually.

D. Other Maintenance Criteria

The Operation and Maintenance Plan must indicate the approximate time that the basin would normally take to drain the Stormwater Quality Storm runoff volume below the ground surface. This normal drain or drawdown time should then be used to evaluate the basin's actual performance. If significant increases or decreases in the drain time are observed, the basin's bottom surface, subsoil, and both groundwater and tailwater levels must be evaluated and appropriate measures taken to comply with the maximum drain time requirements and maintain the proper functioning of the basin. This applies to both surface and subsurface infiltration basins.

The bottom sand layer in a surface infiltration basin should be inspected at least monthly as well as after every storm exceeding one inch of rainfall. The infiltration rate of the soil below the basin may also be retested periodically. If the water fails to infiltrate 72 hours after the end of the storm, corrective measures must be taken. Annual tilling by light equipment can assist in maintaining infiltration capacity and break up clogged surfaces.

Considerations

Infiltration basins can present some practical design problems. When planning for an infiltration structure that provides stormwater quality treatment, consideration should be given to soil characteristics, depth to the groundwater table, sensitivity of the region, and runoff water quality. Particular care must be taken when constructing infiltration structures in areas underlain by carbonate rocks known as Karst landscapes. See Appendix A10 of the Standards for Soil Erosion and Sediment Control in New Jersey for further guidance in Karst landscape areas.

1. Soil Characteristics

Soils are perhaps the most important consideration for site suitability. The first step in determining site suitability would be to consult the appropriate County Soil Survey available through the local Soil Conservation District. Information on soils can also be collected during a geotechnical site investigation to determine foundation conditions for structures. The excavation of an 8 to 10 foot deep test pit or trench is a preferred method for mapping the stratigraphic profile of the site and collecting soil samples. For greater depths and where considerable stratification is anticipated, boring with a continuous splitspoon sampler is appropriate. The recommended minimum depth for subsurface exploration is five feet below the anticipated design depth or to the groundwater table.

2. Construction Specifications

The area planned for the infiltration basin should be cordoned off to prevent heavy equipment from compacting the underlying soils while the remainder of the land development site is under construction. During basin construction, precautions should be taken to prevent soil compaction by construction equipment and sediment contamination. Basin excavation should be performed with equipment placed outside the basin bottom.

Infiltration devices are susceptible to clogging and subsequent failure if significant sediment loads are allowed to enter the structure. Therefore, using an infiltration basin site for construction sediment control is discouraged. When unavoidable, excavation for the sediment basin should be a minimum of two feet above the final design elevation of the basin bottom. Sediment can then accumulate and be removed during site construction without disturbing the final basin bottom, which should be established only after all other construction within its drainage area is completed and the area stabilized. If basin construction cannot be delayed until then and the basin will not be used for sediment control, diversion berms should be placed around the basin's perimeter during all phases of construction to divert all sediment and runoff completely away from the basin. These berms should not be removed until all construction within the basin's drainage area is completed and the area stabilized.

To prevent compaction of the soil below the basin that will reduce its infiltration capacity, basins should be excavated with light earth moving equipment, preferably with tracks or over-sized tires located outside the basin bottom. Once the basin's final construction phase is reached, the floor of the basin must be deeply tilled with a rotary tiller or disc harrow and smoothed over with a leveling drag or equivalent grading equipment.

3. Runoff Quality

The quality of runoff entering an infiltration device is a primary consideration in determining whether infiltration is advisable and, if so, in designing the basin itself. The planning of an infiltration basin must consider which pollutants will be present in the runoff and whether these pollutants will degrade groundwater quality. Certain soils can have a limited capacity for the treatment of bacteria and the soluble forms of nitrogen, phosphorus and other pollutants like road salts and pesticides. Such pollutants are either attenuated in the soil column or go directly to the water table. Unfortunately, the soils that normally have the highest and, therefore, most suitable infiltration rates also have the least ability to treat such pollutants. As a result, pretreatment of soluble pollutants prior to entry into the infiltration basin may be necessary in these soils. Pretreatment measures may include vegetated filter strips, bioretention systems (where the infiltration basin takes the place of the standard underdrain), and certain sand filters. Alternatively, the existing soil below the infiltration basin bottom may be augmented or replaced by soils with greater soluble pollutant removal rates.

Recommendations

A. Pretreatment

As with all other best management practices, pretreatment can extend the functional life and increase the pollutant removal capability of an infiltration basin. Pretreatment can reduce incoming velocities and capture coarser sediments, which will extend the life of the system. This is usually accomplished through such means as a filter strip, a forebay, or a manufactured treatment device. Information on filter strips and manufactured treatment devices is presented in Sections 9.6 and 9.11, respectively.

Forebays can be included at the inflow points to a bioretention system to capture coarse sediments, trash and debris, which can simplify and reduce the frequency of system maintenance. A forebay should be sized to hold the sediment volume expected between clean-outs.

As described above, it should be remembered that the runoff to all subsurface infiltration basins must be pretreated. This pretreatment must provide 80 percent removal of TSS for the Stormwater Quality Storm.

B. Sensitivity of the Area

The planning of an infiltration structure site should consider the geologic and ecological sensitivity of the proposed site. Sensitive areas include FW1 streams, areas near drinking water supply wells, and areas of high aquifer recharge. Infiltration structures should be sited at least 100 feet from a drinking water supply well. They should also be sited away from foundations to avoid seepage problems. Measures should be taken in areas of aquifer recharge to ensure good quality infiltration to protect ground water supply. Infiltration structures should be located away from septic systems to protect the systems from failure.

C. Slopes

Topography of the location is an important consideration for basin operation. Ideally, basin construction should not occur where surrounding slopes are greater than 10 percent. The grading of the basin floor should be as level as possible (with the slope approaching zero) to achieve uniform spreading across the breadth and the length of the basin.

Grading and landscaping throughout the infiltration basin and its components must be designed to facilitate mowing, trimming, sediment and debris removal, and other maintenance activities.